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PROGRAM PLAN
FY11

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Contents

TABLES

FIGURES

Executive Summary

The Stockpile Stewardship Program (SSP) is a highly integrated technical program for maintaining the safety, security, survivability, and reliability of the U.S. nuclear weapons stockpile. The SSP uses past nuclear test data, current and future non-nuclear test data, computational modeling and simulation, and experimental facilities to advance understanding of nuclear weapons and to resolve urgent problems of national interest related to the stockpile. The results of stockpile surveillance and experimental research, combined with modeling and simulation, support the development of engineering programs and an appropriately scaled production capability.

The Advanced Simulation and Computing (ASC)[1] Campaign is a cornerstone of the SSP. It provides simulation capabilities and computational resources to: (a) support the annual stockpile assessment and certification process (b) study advanced nuclear-weapons design, engineering and manufacturing processes (c) analyze accident scenarios and weapons aging (d) support stockpile Life Extension Programs (LEP) and the resolution of Significant Finding Investigations (SFIs). This requires a balanced program, including technical staff, hardware, simulation software, and computer science solutions.

In its first decade, the ASC strategy focused on developing and demonstrating simulation capabilities of unprecedented scale in three spatial dimensions. Now in its second decade, ASC has restructured its business model from one that successfully delivered an initial capability to one that focuses on increasing predictive capability in the simulation tools. The program continues to improve its unique tools for solving progressively more difficult stockpile problems; quantifying critical margins and uncertainties (QMU); and resolving increasingly difficult analyses needed for the SSP. ASC platforms supply the compute cycles for SSP. ASC sees integration as vital to achieving the next level of predictive capability. To that end, ASC activities are coordinated with the Science, Engineering, and Inertial Confinement Fusion (ICF) Campaigns and the Directed Stockpile Work (DSW) program through the Predictive Capability Framework (PCF). The PCF is an integration tool used by the Defense Programs (DP) Campaigns to plan scientific work for tackling difficult problems in select weapons physics and engineering areas.

This Program Plan describes the ASC strategy and deliverables for the FY2011-FY2016 planning horizon. It defines program goals, describes the national work breakdown structure, and details the strategies and associated performance indicators. The plan also includes ASC's proposed Level 1 milestones and top ten risks. To ensure synchronization with SSP needs, the Program Plan will be reviewed and updated annually.

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[1] In FY02 the Advanced Simulation and Computing (ASC) Program evolved from the Accelerated Strategic Computing Initiative (ASCI).

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I. Introduction

On October 2, 1992, a moratorium on U.S. nuclear testing was established. This decision ushered in a new era by which the U.S. ensures confidence in the safety, performance, survivability, and reliability of its nuclear stockpile by means other than nuclear testing. The U.S. also decided to halt new nuclear weapons production. This decision resulted in a need for the nation's stockpile of nuclear weapons to be maintained far beyond its original design lifetime. The Stockpile Stewardship Program (SSP) was established to implement these pivotal policy decisions.

The goal of the SSP is to provide scientists and engineers with technical capabilities for maintaining a credible nuclear deterrent without the use of (1) underground nuclear testing and (2) modernization through development of new weapon systems. To meet this challenge, a new set of above-ground, non-nuclear experimental capabilities was required and archived data from decades of nuclear tests had to be made available to weapon scientists and engineers. An unprecedented level of computational capability was needed to serve as the integrating force for effective use of the collective scientific understanding of the operation of nuclear weapons systems. The Advanced Simulation and Computing Campaign[2]was established to create and shepherd this capability.

Realizing the Vision—Established in 1995 as a critical element of the SSP, ASC is developing the computational capabilities to allow a smooth transition from nuclear test-based certification to science- and simulation-based certification. ASC is a balanced program that focuses on providing simulation capabilities needed to analyze and predict the performance, safety, survivability, and reliability of nuclear weapons. To realize its vision of "predict with confidence," the ASC Program develops advanced weapons physics and engineering codes that incorporate modern theory and models based on current understanding of past nuclear tests and current aboveground experiments. These codes are executed on state-of-the-art high-performance supercomputers that are capable of returning simulation results in a reasonable time span to allow scientists and engineers to make further advances in their understanding of the weapons behavior. The expected outcomes will be predictive simulations that enable assessment and certification of nuclear weapon systems. These simulation capabilities will also help scientists understand, evaluate, and respond to weapons issues such as aging and the effects of changes in parts, materials, and fabrication processes.

The Future of the Nuclear Security Enterprise—The Nuclear Security Enterprise (NSE) today is at a crossroads: on the one hand, NNSA is working to transform itself and revitalize the entire nuclear weapons complex to be smaller, safer, more secure, and more efficient; on the other hand NNSA must be better able to quickly respond to technical problems in the stockpile and to rapidly respond to national security needs as threats against the country evolve and become increasingly unpredictable. Today's NSE needs to meet current stockpile stewardship requirements and respond to

[2] The ASC Campaign was formerly known as the Accelerated Strategic Computing Initiative, or ASCI.

new national security needs. In this spirit, the NNSA has embarked on a process that will make the post-cold war complex more nimble and agile to respond to possible surprises. This process will reduce the footprint of the complex, consolidate capabilities, eliminate redundancies that the country can no longer afford, and reduce reliance on hazardous materials.

It is reasonable for each program in DP, including the ASC Program, to ask itself: what are the *core competencies* at each laboratory that are essential to the stockpile stewardship mission? What are the *redundancies* that do not add value? What *new capabilities* will the laboratories need to develop to support the stockpile stewardship mission and respond to future changes? What *intellectual capital* will need to reside at the laboratories so that the Complex sustains its ability to carry out its evolving mission? By answering these questions, the Nuclear Weapons Complex is envisioned to transition to an integrated National Security Enterprise.

ASC Progress—Considerable progress has been made by establishing two user facilities for production capability computing; one at Lawrence Livermore National Laboratory (LLNL) and the other through the Alliance for Computing at Extreme Scale (ACES) partnership between Sandia National Laboratories (SNL) and Los Alamos National Laboratory (LANL). The establishment of these two centers utilizes the combined strengths of the national laboratories most efficiently in establishing a robust framework for servicing the high-performance computing needs of the Complex.

The ASC coupled physics engineering codes, all resident within the Sierra framework, have been deployed throughout the NNSA laboratories, the Kansas City Plant, a number of DoD facilities, and the Atomic Weapons Establishment in the U.K. The most current version of these codes includes a consolidated thermal-fluid-aero simulation capability and new capabilities in failure modeling, contact and implicit-explicit algorithm interoperability.

ASC's simulation tools for the nuclear stockpile have natural applications for a broader national security mission. In conjunction with developing science-based, predictive simulations capabilities for nuclear weapons assessment, ASC has supported the research, development, and application of these tools for nuclear forensics — the science of post-detonation analysis for the identification of the composition of the nuclear device. ASC delivered initial operational capabilities with quantified uncertainties for the partner agencies in 2010. ASC is committed to further explore areas of national security where the ASC simulation toolset may enable faster turnaround of operations, higher-fidelity simulations, and improved scientific understanding of the underlying physical phenomena. These mission areas include nonproliferation applications such as the development of nuclear detection technology and analysis of seismic and optical signal monitoring. There are also counterterrorism applications such as analyses of Improvised Nuclear Devices (IND) and Radiological Dispersal Devices (RDD), and support of the Joint Technical Operations Team's Emergency Response mission.

ASC Driver: Predictive Capability—Before the advent of ASC, predictive capability for the weapons program was out of reach. The pre-ASC computing power only allowed for what would be considered coarse-mesh weapons physics and engineering simulations by today's standards. Empirical and sometimes arbitrary parameters, or knobs, were used in lieu of detailed physics modeling. Slow processors, small memory, and poor communication bandwidth were some of the obstacles faced by the computational scientists. The lack of computing power also meant that minimal resources could be spent on verification and validation, thus necessitating greater reliance on subjective judgments in the determination of the correctness of the simulations.

As the last of the weapons designers, physicists, and engineers with actual underground nuclear testing experience retire, NNSA is moving from depending on a mostly "expert judgment" based certification process to more reliance on a science-based methodology that will allow defensible stockpile decisions to be made without returning to underground nuclear testing. Recently, "Quantification of Margins and Uncertainties (QMU)" has become the methodology employed by DP for nuclear weapons assessment. In the QMU methodology, "margins" and "uncertainties" need to be quantified based on a scientific understanding of the stockpile system. The NSE plans to take an integrated approach that combines the use of experimental tools, analytical and numerical models, integrated codes, and high-performance computing tools, to develop an increasingly mature *predictive capability* that will form the basis for the QMU methodology. Simulation science is at the center of this predictive capability.

The ASC Program is charged to provide, for the NSE, capacity and capability computing power, software and integrated multi-scale, multi-physics codes that run on these platforms, development and implementation of detailed physics and engineering models, and verification and validation of simulation tools. ASC has fostered innovations and provided leadership-class computing power to the nuclear weapons simulations community, enabling the scientists and engineers to explore long-standing physics, engineering, and algorithmic issues and to bring scientific rigor to simulation science. It is in this modern environment that one can now consider the possibility of removing historical *knobs* and replacing *ad hoc* models with ones grounded in physical reality.

ASC, however, must collaborate with other Campaigns to provide increased predictive capability for the NSE. For instance, the credibility of simulations needs to be affirmed by experiments; theory and modeling work is conducted in all of science and engineering; and stockpile assessment requirements are set by DSW. To utilize best the resources of the NSE, NNSA Defense Programs has begun crafting the **Predictive Capability Framework** (PCF) to combine best the strengths and capabilities of each Campaign. This framework is a program planning and integration tool for activities that are needed to improve fundamental understanding of the physics of nuclear weapon systems.

Major ASC Objectives—To meet the science and simulation requirements of the SSP, the ASC Program's core mission, vision, and goal are as follows:

Mission: Provide leading-edge, high-end simulation capabilities needed to meet weapons assessment and certification requirements.

Vision: Predict, with confidence, the behavior of nuclear weapons, through comprehensive, science-based simulations.

Goal: Deliver accurate simulation and modeling tools, supported by necessary computing resources, to maintain nuclear deterrence.

Development and implementation of comprehensive methods and tools for certification, including simulations, are top DP priorities. To ensure its ability to respond to stockpile needs and deliver accurate simulation and modeling tools, ASC's strategic goals for the next ten years are focused on[3]:

- Improving the confidence in prediction through simulations;
- Integrating the ASC Program with certification methodologies;
- Developing the ability to quantify uncertainty and confidence bounds for simulation results;
- Increasing predictive capability through tighter integration of simulation and experimental activities;
- Providing the necessary computing capability to code users, in collaboration with industrial partners, academia, and government agencies.

The products of ASC serve as the integrators for all aspects of the NSE, from assisting the manufacturing plants to the full stockpile life cycle. The ASC tools also provide capabilities for studies and assessments of proliferant devices and their effects, vulnerabilities to electromagnetic pulse, and advanced weapon concepts that could respond to possible new threats.

Strategy—TASC has adopted a strategy that emphasizes providing a science basis for models used in the weapons simulation codes and a deeper understanding, in quantitative terms, of their predictive capabilities and uncertainties in order to enable risk-informed decisions about the performance, safety, and reliability of the stockpile.

ASC and the other Campaigns will be integrated through the PCF. The PCF is measured by progress in four *predictive* capabilities: Safety and Surety, Nuclear Explosive Package Assessment, Engineering Assessment, Hostile Environments Outputs and Effects, compared to the progress of five *enabling* capabilities: (1) theory and model development (2) integrated code and algorithm development (3) computational and experimental facilities (4) experimental data acquisition (diagnostics development) and analysis (5) QMU and Verification & Validation (V&V) capabilities. The linkage of the enabling capabilities to major areas of interest in weapons physics and engineering allows the synchronization of the delivery of experimental platforms and data and the development of advanced computational platforms, models, and integrated codes for addressing the

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[3] Source: *ASC Strategy*, NA-ASC-100R-04-Vol.1-Rev.0, August 2004; http://www.sandia.gov/NNSA/ASC/pdfs/Strat10yr_MT.pdf

major scientific uncertainties associated with nuclear weapons. The ASC strategy is aligned with the PCF to maximize the leverage of other Campaigns toward a demonstrable predictive capability.

The ASC strategy has both short- and long-term components. The goal of the short-term component is to meet the continuing and time-constrained needs of stockpile stewardship, in particular, SFIs, LEPs, Annual Assessments, and Major Assembly Releases. As modern simulation capabilities have matured demonstrably, more and more stockpile issues are being resolved through the use of modern 3-D integrated codes with high-fidelity models and enhanced performance. The fidelity and performance of these codes will continue to be improved so that they become increasingly responsive to any potential stockpile problems that might be uncovered in the surveillance process.

The long-term component of the strategy is to ensure movement toward a science-based, predictive capability that will enhance confidence in the simulation results. To ensure that simulation results are grounded in physical reality and to provide a foundation for scientifically based decisions, the representation of weapons behavior must also be supported by an increased focus on V&V and Uncertainty Quantification (UQ). To translate this vision of science-based weapons simulation into reality, the ASC Program has embarked upon the formulation of strategies for specific application areas. The three application areas under consideration are Integrated Codes (IC), V&V, and Physics and Engineering Models (PEM). The IC strategy was published in FY09[4] and work on the PEM and V&V strategies has begun, with publication scheduled for FY11. These developing strategies are complementary to the ASC Platform Strategy,[5] which provides both stable compute cycles for the nuclear weapons program as well as innovation in high-performance computing for predictive nuclear weapons calculations in the next decade.

The ASC Code Strategy describes a vision to develop simulation tools that are essential to stockpile stewardship and broader national security missions. The overall objectives of the Code Strategy are to enable world-class predictive sciences, and QMU-based certification, all within a pervasive UQ discipline. Based on these objectives, a national simulation portfolio for weapons sciences and engineering is established to ensure adequate capability to perform the stockpile stewardship mission and peer review. In addition, the code strategy identifies areas of computer and computational sciences for focused investment, in order to respond to changes in DP mission, computer architecture, and possibly the nuclear weapons posture of the nation.

The *ASC PEM Strategy*, current under development, describes a vision of "enabling a science-based predictive capability." Underlying the ASC simulation codes are the models that describe material behavior and physical phenomena for all of the materials important to the mission. The objectives of the PEM strategy are to develop models for all the key materials occurring in weapons from manufacture to retirement, to produce robust numerical implementations of the models into the simulation codes, and to

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[4] http://www.sandia.gov/NNSA/ASC/pdfs/ASC-Code-Strategy.pdf
[5] http://www.sandia.gov/NNSA/ASC/pdfs/AscPlatform2007.pdf

develop material property databases for use by the codes of all materials relevant to the DP mission. Materials issues in the stockpile are varied and ever changing, so the program must maintain a broad materials expertise which can adapt to changing needs of the program. The PEM element of ASC interacts closely with the experimental elements of the Science and Engineering Campaigns.

The *ASC V&V Strategy*, currently in development, will establish credibility in modeling by assessing simulation capability, advising the simulation community, and advocating simulation capability. The objectives of the V&V strategy are to provide quantified credibility to simulations, facilitate communications among those who perform simulations and those who use simulations to make decisions, and advance simulation science. Like the code strategy, the V&V strategy also needs to anticipate and respond to uncertainties of the future; however, it aims to provide a basic, broad set of action plans that will be applicable for the next decade and adaptable to the ever-changing landscape of the NSE.

Accomplishments and Planned Contributions—Throughout its history, the ASC Campaign has demonstrated pioneering capabilities by proof-of-principle calculations. The continued success of the Campaign is a testament to the breadth and depth of scientific capabilities and the desire to push the frontier of science at the NNSA laboratories. A brief list of past, present, and planned contributions to the SSP is given below.

In FY1996, ASCI Red was delivered. Red, the world's first teraFLOPS supercomputer, was upgraded to more than 3 teraFLOPS in FY1999 and was retired from service in September 2005.

In FY1998, ASCI Blue Pacific and ASCI Blue Mountain were delivered. These platforms were the first 3-teraFLOPS systems in the world and have both since been decommissioned.

In FY2000, ASCI successfully demonstrated the first-ever 3D simulation of a nuclear weapon primary explosion and the visualization capability to analyze the results; ASCI successfully demonstrated the first-ever 3D hostile-environment simulation; and ASCI accepted delivery of ASCI White, a 12.3-teraFLOPS supercomputer, which has since been retired from service.

In FY2001, ASCI successfully demonstrated simulation of a 3D nuclear weapon secondary explosion; ASCI delivered a fully functional Problem Solving Environment for ASCI White; ASCI demonstrated high-bandwidth distance computing between the three national laboratories; and ASCI demonstrated the initial validation methodology for early primary behavior. Lastly, ASCI completed the 3D analysis for a stockpile-to-target sequence for normal environments.

In FY2002, ASCI demonstrated 3D system simulation of a full-system (primary and secondary) thermonuclear weapon explosion, and ASCI completed the 3D analysis for an STS abnormal-environment crash-and-burn accident involving a nuclear weapon.

In FY2003, ASCI delivered a nuclear safety simulation of a complex, abnormal, explosive initiation scenario; ASCI demonstrated the capability of computing electrical responses of a weapons system in a hostile (nuclear) environment; and ASCI delivered an operational 20-teraFLOPS platform on the ASCI Q machine, which has been retired from service.

In FY2004, ASC provided simulation codes with focused model validation to support the annual certification of the stockpile and to assess manufacturing options. ASC supported the life-extension refurbishments of the W76 and W80, in addition to the W88 pit certification. In addition, ASC provided the simulation capabilities to design various non-nuclear experiments and diagnostics.

In FY2005, ASC identified and documented SSP requirements to move beyond a 100 teraFLOPS computing platform to a petaFLOPS-class system; ASC delivered a metallurgical structural model for aging to support pit-lifetime estimations, including spiked-plutonium alloy. In addition, ASC provided the necessary simulation codes to support test readiness as part of NNSA's national priorities.

In FY2006, ASC delivered the capability to perform nuclear performance simulations and engineering simulations related to the W76/W80 LEPs to assess performance over relevant operational ranges, with assessments of uncertainty levels for selected sets of simulations. The deliverables of this milestone were demonstrated through two-dimensional (2D) and 3D physics and engineering simulations. The engineering simulations analyzed system behavior in abnormal thermal environments and mechanical response of systems to hostile blasts. Additionally, confidence measures and methods for UQ were developed to support weapons certification and QMU Level 1 milestones.

In FY2007, ASC supported the completion of the W76-1 and W88 warhead certification, using quantified design margins and uncertainties; ASC also provided two robust 100-teraFLOPS-platform production environments by IBM and CRAY, supporting DSW and Campaign simulation requirements, respectively. One of the original ASCI program Level 1 milestones was completed when the ASC Purple system was formally declared "generally available." This was augmented by the 360-teraFLOPS ASC BlueGene/L system, which provided additional capability for the Science Campaigns. The ASC-funded partnerships with Sandia National Laboratories (SNL)/Cray and Lawrence Livermore National Laboratory (LLNL)/IBM have transformed the supercomputer industry. By mid-2007, there were at least 34 "Blue Gene Solution" systems on the Top 500 list and 38 Cray sales based on the SNL Red Storm architecture.

In FY2008, ASC delivered the codes for experiment and diagnostic design to support the CD-4 approval on the National Ignition Facility (NIF). An advanced architecture platform capable of sustaining a 1-petaFLOPS benchmark, named Roadrunner, was sited at Los Alamos National Laboratory (LANL). SNL and LANL established the collaborative Alliance for Computing at Extreme Scale (ACES) for the purpose of providing a user facility for production capability computing to the Complex. Plans were made for the Cielo capability computing platform, the first platform to be hosted through ACES, to be procured and sited at LANL.

In FY2009, ASC released improved codes to support stockpile stewardship and other nuclear security missions, including secure transportation, NSE infrastructure, and nuclear forensics—specifically, a suite of physics-based models and high-fidelity databases were developed and implemented to support National Technical Nuclear Forensics (NTNF) activities.

In FY2010, ASC continued to deliver science-based simulation tools to support annual assessments and the next generation of LEPs. Code suite physics and optimization were completed in support of the NTNF program and High Energy Density Physics experimental program. The Energy Balance Level 1 milestone was completed using ASC codes and the Predictive Capability Assessment Project was begun under the V&V program element. An initial assessment of new capabilities in a primary burn code was performed. ASC also provided tools for both experiment and diagnostic design to support the indirect-drive ignition experiments on the NIF. In addition, ASC continued to provide national leadership in HPC and deploy capability and capacity platforms in support of DP Campaigns. Roadrunner, the advanced architecture petaFLOP hybrid HPC was formally transitioned to production computing for weapons applications.

In FY2011, ASC will continue delivering science-based simulation tools for annual assessments and next-generation LEPs, focusing on improved physics, fidelity, and calculations in support of DSW and the National Code Strategy. The methodology for predictive capability assessment will be demonstrated in FY11 for a limited set of simulations common to both physics laboratories. The ability to simulate full system performance near thresholds where data are sparse will be assessed. Cielo, the next generation ASC National User Facility, will be in operation, replacing Purple to provide capability computing cycles for the SSP. Development of the advanced architecture Sequoia HPC will continue, with a focus on Scalable Applications Preparation and outreach. Installation and operation of the next-generation Tri-Lab Linux Capacity Clusters and associated common user environment will continue across the three NNSA laboratories.

In FY2012 and beyond, ASC will focus on strengthening the science-basis and driving down uncertainties for weapons simulations to a degree that NNSA can ultimately, and credibly, claim predictive capability; instituting a robust, formalized peer review system; increasing the number of production computing cycles to support increased use of simulation in stockpile activities; reliance on UQ in weapons decisions; and pursuing exascale computing to meet time-urgent, future capability needs.

ASC Level 1 Milestones—ASC will deliver its next major contributions in the form of a proposed set of six Level 1 milestones. Level 1 milestones track ASC's progress toward accomplishing its strategic goals, meeting its performance measures, and providing the predictive capabilities and computing power necessary to meet the SSP's needs. Table 1 identifies ASC's interfaces with other DP components needed to accomplish its Level 1 milestones.

Table 1. ASC Level 1 *Proposed* Milestone and Interfaces with DP Components from FYs 2011–2016

Milestone Title	Level	FY	Completion Date	Site(s)	Participating Program Offices
Develop, implement, and apply a suite of physics-based models and high-fidelity databases necessary for predictive simulation of the initial conditions for primary boost (initial conditions 1).	1	FY12	Q4	LANL LLNL	Science Campaigns ASC Campaign
Assessment of weapon surety status.	1	FY13	TBD	SNL	ASC Campaign Engineering Campaigns
Demonstrate predictive capability for weapon system response to short-pulsed neutrons in a hostile radiation environment.	1	FY13	TBD	SNL	ASC Campaign
Baseline demonstration of UQ aggregation methodology for full-system weapon performance prediction.	1	FY14	TBD	LANL LLNL SNL	Science Campaigns ASC Campaign DSW
Full-system safety assessment.	1	FY14	TBD	SNL	ASC Campaign Engineering Campaigns
Advanced models to support initial conditions for boost (initial conditions 2).	1	FY14	TBD	LANL LLNL	Science Campaigns ASC Campaign

II. ASC Program Structure

To meet its mission, the ASC Campaign consists of five subprograms. These subprograms include: (1) Integrated Codes (IC); (2) Physics and Engineering Models (PEM); (3) Verification and Validation (V&V); (4) Computational Systems and Software Environment (CSSE); and (5) Facility Operations and User Support (FOUS).

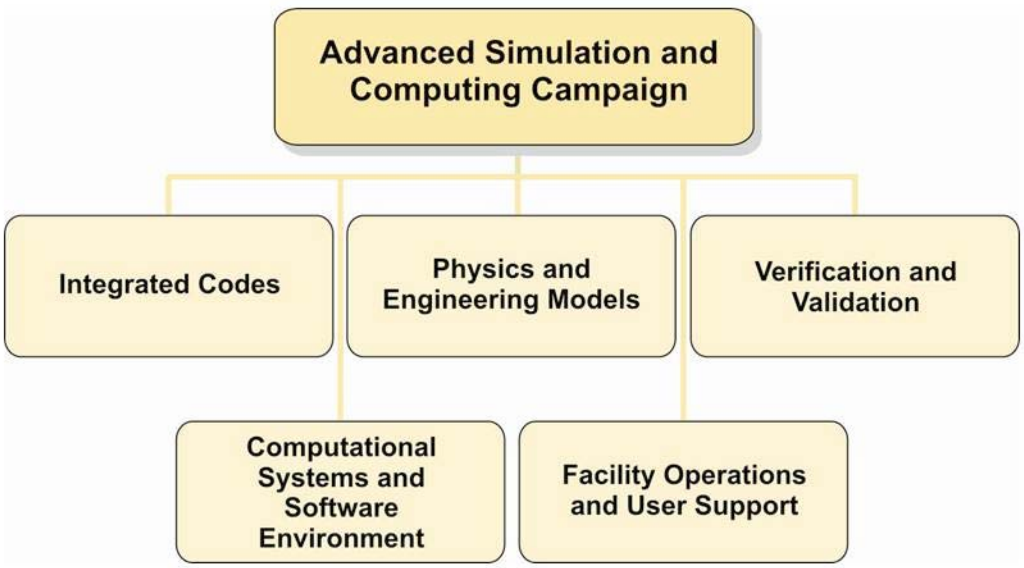


Figure 1. Subprograms of the ASC Campaign

Below is a brief description of the sub-programs. Strategic goals of each subprogram are listed in Table 2. The OMB's performance indicators for the Campaign are listed in Table A-1 of the Appendix A.

Integrated Codes (IC)

This sub-program produces the weapons simulation codes, particularly the new weapons codes created over the last decade; has responsibility for the engineering codes, emerging codes, and specialized codes, and maintains selected legacy codes. It also fosters interactions with the larger scientific and academic community. Codes produced by this sub-program are used by all elements of the SSP. It is these codes that serve as the integrating elements of the ASC Program, incorporating the products of the ASC Physics and Engineering Models sub-program, and serving as the objects to be examined and assessed in the ASC Verification and Validation (V&V) sub-program. The IC subprogram sets requirements for, and serves as, the principal consumer of products from the Computational Systems and Software Environment and the Facility Operations and User Support sub-programs.

The DSW program element is an immediate customer of the IC sub-program, using the codes directly for the full range of stockpile assessment and certification objectives. In turn, DSW requirements drive near-term code activities and longer-term development of new capabilities. The National Ignition Campaign uses the codes on ASC computing resources to meet mission goals, including National Ignition Facility (NIF). The Science and Engineering Campaigns are both customers and suppliers for the IC sub-program, as they use these codes to design and analyze stockpile-relevant experiments, to advance fundamental understanding of weapons physics and engineering, and then reciprocally to provide scientific discovery, physical data, and certification methodologies that are used to improve the codes and guide their use.

The IC sub-program has five major product areas. Significant investment of resources goes to the area of **Modern Multi-Physics Codes**, which are 3-D codes that contain the latest fruits of scientific research for the stockpile stewardship mission. While the multi-physics codes are rapidly superseding previous generation codes, the second product area, **Legacy Codes** facilitates the transition: as users learn to use the modern multi-physics codes, as code developers migrate physics capabilities not yet implemented in the modern codes, and as a reference point for weapons analysts who are developing new baseline models using the modern multi-physics codes. **Engineering Codes** are the third product area of this sub-program, providing comparable advanced simulation capability for addressing the most challenging engineering-related aspects of nuclear weapon system safety, survivability, performance, and reliability.

The other two major product areas are considered supporting areas. One is **Focused Research, Innovation, and Collaboration**, which targets needed future technologies, algorithms, and computational methods, and draws from expertise at the laboratories and in the larger scientific and academic community. Interactions with the academic community include university contracts and activities such as the ASC Predictive Science Academic Alliance Program and Computational Science Graduate Fellowships that encourage laboratory-university collaboration. The second supporting product area is **Emerging and Specialized Codes**, which provides developmental products built on promising, emerging technologies. It also provides specialty codes that simulate complex processes in unique environments or provide unique capabilities closely tied to user applications for problem setup and analysis.

Physics and Engineering Models (PEM)

This sub-program develops microscopic and macroscopic models of physics and material properties, as well as special-purpose physics codes required to investigate specific physical phenomena in detail. This program works with the IC subprogram to develop new models, and is responsible for the initial validation and incorporation of new models into the integrated codes.

There is also extensive integration between the model development program and the SSP experimental programs executed by the DP Science Campaigns, the ICF Campaign, and the Engineering Campaign. Functional requirements for this sub-program are established by assessment of known uncertainties and prioritized via a QMU analysis.

Verification and Validation (V&V)

This sub-program element provides a scientifically based measure of confidence in simulation capabilities used for the resolution of high-consequence nuclear stockpile problems. V&V, as a multidisciplinary process, provides a technically rigorous foundation of credibility for computational science and engineering calculations by developing and implementing tools for accessing numerical approximations of physical models, demonstrating model capabilities in various operational and functional regimes, assigning and quantifying uncertainties, and documenting the pedigree of the simulation tools.

As the NSE bases more of its high-consequence nuclear stockpile decisions on simulations, it is imperative that the simulation tools possess demonstrated credibility. Verification activities focus on demonstrating that the weapons codes are solving the equations correctly. These may include development of a Verification Suite, a set of tests for which all codes must demonstrate correct convergent behavior, and verification methods development, where new procedures such as solution verification are developed and studied to assess their utility in verifying a code. Validation activities ensure that the weapons codes are solving the correct equations, that is, the *physics and engineering models* are correct. These may include examining sub-components of the codes to make comparisons to above-ground experiment (AGEX) data, examining integral calculations to make comparisons to underground test (UGT) data, exploring the regime-of-applicability for specific models, and the development of a Validation Suite against which a code must demonstrate the degree to which a simulation with the code can match available data, with quantified results and error estimates.

In addition to V&V, the uncertainty in the simulation output must be quantified. The predictions from weapons physics and engineering codes output must be understood in the context of all the uncertainties in these databases and in the various physics and numerical approximations. V&V is developing UQ procedures as a part of the foundation to the QMU methodology of weapons certification. V&V also strives to set the standard for documentation and drive advances in numerical and physics modeling.

Currently, the physics and engineering simulations supporting stockpile decisions include an element of calibration to the integral AGEX and UGT data. Thus, a necessary complement to the scientifically rigorous V&V process is an evaluation of the impact of this calibration on predictability and the quantification of uncertainties. Exercising the simulation tools without calibration and comparing to the current stockpile simulation results permits monitoring progress away from calibration toward predictivity.

The program goal is to deliver a coherent set of assessments and tools necessary to support the risk informed decision of maintaining the safety, surety, survivability, and reliability of the U.S. nuclear stockpile.

Computational Systems and Software Environment (CSSE)

This sub-program builds integrated, balanced, and scalable computational capabilities to meet simulation requirements of NNSA. It strives to provide a stable and seamless computing environment for ASC capability, capacity, and advanced systems. The complexity and the scale of nuclear weapons performance and analysis simulations require ASC to be far in advance of the mainstream high-performance computing community. To achieve its predictive capability goals, ASC must continue to invest in, and influence the evolution of, computational environments. At the same time, however, CSSE must also provide the stability that ensures productive system use and protects the large ASC investment in its simulation codes.

Along with the powerful capability, capacity, and advanced systems that ASC will field, the supporting software infrastructure that CSSE is responsible for deploying on these platforms includes many critical components, from system software and tools, to Input/Output (I/O), storage and networking, to pre- and post-processing visualization and data analysis tools. Achieving this deployment objective requires sustained investment in applied research and development activities to create technologies that address ASC's unique mission-driven need for scalability, parallelism, performance, and reliability.

In the next decade, both the enhancement of future predictive capabilities and the achievement of DSW simulation deliverables will demand ever more powerful and sophisticated simulation environments. CSSE will meet these requirements by providing mission-responsive computational environments for UQ analyses, weapons science and engineering studies, and enhanced predictive capability. The immediate focus areas include moving toward a standardized user environment, deploying more capacity computing platforms, developing petascale computing capability for integrated weapons and engineering codes, and making overall strategic investments so that ASC can continue to meet the requirements of the program at an acceptable cost. CSSE's longer-term efforts in applied research and development will support the exascale level performance, as stated in the *ASC Roadmap*[6].

Facility Operations and User Support (FOUS)

This sub-program provides both necessary physical facility and operational support for reliable production computing and storage environments as well as a suite of user services for effective use of ASC tri-lab computing resources. The designers, analysts, and code developers of the NSE provide functional and operational computational requirements for FOUS.

The scope of facility operations includes planning, integration, and deployment; continuing product support; software license and maintenance fees; procurement of operational equipment and media; and quality and reliability activities. Facility Operations also covers physical space, power and other utility infrastructure, and

[6] *The ASC Roadmap*, NA-ASC-105R-6-Vol.1-Rev 0; http://www.sandia.gov/NNSA/ASC/pdfs/ASC-RdMap1206r.pdf

LAN/WAN networking for local and remote access, requisite system administration, and cyber-security and operations services. Industrial and academic collaborations are an important part of this sub-program.

The scope of User Support also includes planning, development, integration and deployment, continuing product support, and quality and reliability activities. Projects and technologies include computer center hotline and help-desk services, account management, web-based system documentation, system status information tools, user training, trouble-ticketing systems, and application analyst support. Collaborations are also an important part of the FOUS sub-program.

Strategic goals for the five sub-programs are listed below. ASC performance measures are described in Appendix A.

Table 2. ASC Strategic Goals

Subprogram	Strategic Goals
INTEGRATED CODES	Releasing improved versions of modern multi-physics and engineering codes and supporting the users who apply these codes to stockpile issues, implementing models to meet user requirements, and enhancing the codes for increased predictive capability and applications breadth.
	Researching, developing, and maintaining algorithmic capabilities for codes and leverage advances of the external scientific community for programmatic code activities.
	Delivering capabilities and prototype applications for classes of experiments or phenomena requiring specialized physics and engineering models. Implementing promising approaches in special-purpose codes for development and evaluation for broader use in integrated codes.
PHYSICS AND ENGINEERING MODELS	Developing and implementing validated models for use in the ASC simulation codes.
	Developing fundamental understanding of underlying physical phenomena to support development of high-fidelity models.
	Developing and deploying improved material data libraries (equation-of-state, nuclear data, opacities, material constitutive properties, etc.) and demonstrated improvement in ASC simulations utilizing these libraries.
VERIFICATION AND VALIDATION	Developing a national V&V Strategy.
	Assessment of major simulation uncertainties.
	Demonstrating UQ methodology for QMU.
COMPUTATIONAL SYSTEMS AND SOFTWARE ENVIRONMENT	Providing users a stable, secure, integrated tri-lab computing environment for all classified ASC computing resources.
	Investing in development of production hardware and software systems capable of running the largest simulations addressing NNSA requirements.
	Developing and implementing problem setup, data management, data analysis, and visualization tools for ASC weapons simulations
	Collaborating with vendors and other government programs (e.g., DOE Office of Science, Defense Advanced Research Projects Agency [DARPA], and National Security Agency [NSA]) with a new focus on Advanced Systems to support the path to exascale computing before 2020.

Subprogram	Strategic Goals
FACILITY OPERATIONS AND USER SUPPORT	Providing continuous and reliable operation and support of production computing systems and all required infrastructure to support these systems on a 24 hours a day, 7 days a week basis. The emphasis is on providing efficient production quality support of stable systems.
	Prioritizing capability computing resources under the ASC Capability Compute System Scheduling Governance Model.
	Ensuring that the physical plant has sufficient resources (such as space, power, cooling) to support future computing systems.
	Providing, developing, and maintaining a wide area infrastructure (links and services) that enables remote access and data movement across ASC sites. Enable remote access to ASC applications, data, and computing resources that will support computational needs at the plants.
	Providing user services and help desks for laboratory ASC computers.

III. Integration

Continual collaboration among ASC, Campaigns, and DSW is a major strength of the SSP. Joint efforts in software development, code verification and validation, and tool-suite application are good examples of this collaboration.

Relationship of ASC to Directed Stockpile Work—The DSW Program conducts the surveillance, maintenance, refurbishment, and manufacturing activities for nuclear weapons in the stockpile. This program serves as the principal DP interface with the Department of Defense (DoD). DSW is responsible for activities that lead to the continuing assessment of the performance, safety, survivability, and reliability of aging nuclear weapons and the certification of refurbished weapons. ASC supports the DSW Program by providing advanced simulation and modeling capabilities and technologies that support annual assessment activities, evaluation and resolution of SFIs, and certification of refurbished weapon systems.

Relationship of ASC to the Defense Science Campaigns—Within Defense Programs, the Office of Research and Development of National Security Science and Technology is the umbrella organization for the Campaigns, including ASC, Defense Science, Engineering, DSW Research and Development, and the National Ignition Campaign.

Individually, these Campaigns develop the science basis for stockpile stewardship using facilities such as: the Dual Axis Radiographic Hydrodynamic Testing (DARHT) facility at Los Alamos, the Microsystems and Engineering Sciences Applications (MESA) facility at Sandia, and the National Ignition Facility (NIF) at Lawrence Livermore. The Campaigns produce high-quality physics data, which ASC incorporates into its integrated codes, either to be used as fundamental data or to inform models. The ASC integrated codes in turn are used by these Campaigns to design experiments, prioritize model development efforts, perform discovery, and assess model uncertainties.

In the post-nuclear-testing era, the integration of theory and modeling, experiments, and simulation capabilities is critical to our ability to assess the safety, reliability, and performance of the nuclear stockpile. The need for integration has prompted the Campaigns to develop cooperatively, the PCF.

As discussed earlier, the PCF is a program planning and integration tool for activities to improve fundamental understanding of nuclear weapon systems physics. The PCF allows DP to manage the Campaigns as one integrated program with respect to the predictive capability areas of Safety and Surety, Nuclear Explosive Package Assessment, Engineering Assessment, and Hostile Environments, Outputs and Effects. (The time-dependent and desired states of these four areas are described in the PCF “Tier 1 matrix”). Such integration allows the synchronized delivery of experimental platforms and data, and the development of advanced computational platforms and models to address the major scientific uncertainties associated with nuclear weapon systems.

Relationship of ASC to the Department of Energy (DOE) Office of Science and other Government Agencies—Certain technical problems that arise in petascale and upcoming exascale computing are universal to scientific simulation and apply equally well to applications within the NNSA, DOE's Office of Science, and other government agencies such as the NSA, DoD, and DARPA. This includes I/O and archival management of large scientific data sets, the validation and debugging of large-scale parallel applications, the analysis and visualization of petabyte data sets, the operating systems for high-performance computing, and mathematical algorithms and software for solving complex problems.

While there are significant differences in the detailed nature of the scientific problems addressed, there is still much to be gained by exploiting the natural synergy between high-performance computing goals and objectives of ASC and those of similar governmental programs. Accordingly, ASC is collaborating with these other agencies to identify areas of common interest and to establish appropriate coordination of efforts.

IV. Risk Management

Risk management is a process for identifying and analyzing risks, as well as planning and executing mitigation or contingency plans to minimize potential consequences of identified risks. A "risk" is defined by (1) a future event, action, or condition that might prevent the successful execution of strategies or achievement of technical or business objectives and (2) the risk-exposure level, defined by the likelihood or probability that an event, action, or condition will occur, and the consequences if that event, action, or condition does occur. Table 3 summarizes ASC's top ten risks, which are managed and tracked.

Table 3. ASC Top 10 Risks[7]

No	Risk Description	Risk Assessment			Mitigation Approach
		Consequence	Likelihood	Risk Exposure	
1	Compute resources are insufficient to meet capacity and capability needs of designers, analysts, DSW, or other Campaigns.	High	High	HIGH	Integrate program planning with DSW and other Campaigns, to ensure requirements for computing are understood and appropriately set; maintain emphasis on platform strategy as a central element of the program; pursue plans for additional and cost-effective capacity platforms.
2	Designers, analysts, DSW, or other Campaign programs lack confidence in ASC codes or models for application to certification/qualification.	Very High	Low	MEDIUM	Maintain program emphasis on V&V; integrate program planning with DSW and other Campaign programs to ensure requirements needed for certification/qualification are properly set and met.
3	Inability to respond effectively with modeling & simulation (M&S) capability and expertise in support of stockpile requirements – near or long term, planned or unplanned (LEP, SFIs, etc.).	Very High	Low	MEDIUM	Integrate program planning, particularly technical investment priority, with DSW and other Campaign programs to ensure capability and expertise is developed in most appropriate areas; retain ability to apply legacy tools, codes, models.
4	Base of personnel with requisite skills, knowledge, and abilities erodes.	High	Moderate	MEDIUM	Maintain emphasis on "best and brightest" personnel base, with Institutes, Research Foundations, and University programs, as central feeder elements of the program.

[7] Most recent risk assessment can be found in the current ASC Implementation Plan

No	Risk Description	Risk Assessment			Mitigation Approach
		Consequence	Likelihood	Risk Exposure	
5	Advanced material model development more difficult, takes longer than expected.	Moderate	High	MEDIUM	Increase support to physics research; pursue plans for additional computing capability for physics and engineering model development
6	Data not available for input to new physics models or for model validation.	High	Moderate	MEDIUM	Work with Science and Engineering Campaigns to obtain needed data; propose relevant experiments.
7	Infrastructure resources are insufficient to meet designer, analyst, DSW, or other Campaign program needs.	High	Low	MEDIUM	Integrate program planning with DSW and other Campaigns, to ensure requirements for computing are understood and appropriately set; maintain emphasis on system view of infrastructure and PSE strategy, as central elements of the program.
8	External regulatory requirements delay program deliverables by diverting resources to extensive compliance-related activities	Moderate	Low	MEDIUM	Work with external regulatory bodies to ensure that they understand NNSA's mission, ASC's mission, and the processes to set and align requirements and deliverables, consistent with applicable regulations.
9	Inadequate computational environment impedes development and use of advanced applications on ASC platforms.	Moderate	Very Low	LOW	Integrated planning between program elements to anticipate application requirements and prioritize software tools development and implementation.
10	Fundamental flaws discovered in numerical algorithms used in advanced applications require major changes to application development.	Moderate	Very Low	LOW	Anticipate or resolve algorithm issues through technical interactions on algorithm research through the Institutes, ASC Centers, and academia, and focus on test problem comparisons as part of software development process.

V. Program Funding

ASC funding is allocated to cover people, hardware, and contract costs. The budget is reported monthly by ASC laboratory resource analysts and by laboratory management. Funding and costs are tracked and reported at the product level using DOE's Budget and Reporting (B&R) codes and Financial Information System.

VI. Roles and Responsibilities

Program changes (that affect cost, schedule, and scope) discussed in this year's program plan are managed in accordance with clarified roles of federal and laboratory managers.[8] In general, federal managers prioritize the elements of the national program, allocate resources at the Level 3 or sub-program level, resource-load at the Level 4 or products level, and monitor and evaluate the scope and execution of the program. Laboratory managers develop and execute technical projects. They are responsible for maintaining the Level 3 sub-program budgets, as allocated by HQ. They also manage the scope, schedule, and budget of their individual projects, as described in the *ASC Implementation Plan*.

[8] "Role of the Federal Laboratory Program Managers," ASC Business Model, NA-ASC-104R-05-Vol. 1-Rev.0; http://www.sandia.gov/NNSA/ASC/pdfs/ASC-Bus-Mod-2005-w.pdf

Appendix A.
Performance Measures

Table A-1. ASC Performance Measures

Goal: Provide the computational science and computer simulation tools necessary for understanding various behaviors and effects of nuclear weapons for responsive application to a diverse stockpile and scenarios of national security.

Performance Indicators	FY 2007 Results ®	FY 2008 Results	FY 2009 Results	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016	Endpoint Target (T)
Secretarial Goal: Security: Reduce nuclear dangers and environmental risks **GPRA Unit Program Number:** 30, Advanced Simulation and Computing Campaign											
Adoption of ASC Modern Codes: The cumulative percentage of simulation runs that utilize modern ASC-developed codes on ASC computing platforms as measured against the total of legacy and ASC codes used for stockpile stewardship activities. (Long-term Outcome[9]	R: 63% T : 63%	R: 72% T: 72%	R: 80% T: 80%	T: 85%	T: 90%	T: 95%	T: 100%	N/A	N/A	N/A	By 2013, ASC-developed modern codes are used for all simulations on ASC platforms. Adoption of Modern ASC Codes will enable a responsive simulation capability for the nuclear security enterprise. This measure is meant to show how quickly ASC codes are being adopted by the user community in place of legacy codes.
Reduced Reliance on Calibration: The cumulative percentage reduction in the use of calibration "knobs" to successfully simulate nuclear weapons performance. (Long-term Outcome)[a]	R: 8% T : 8%	R: 16% T: 16%	R: 25% T: 25%	T: 30%	T: 35%	T: 40%	T: 45%	T: 50%	T: 55%	T: 60%	By 2024, 100% of selected calibration knobs affecting weapons performance simulation have been replaced by science-based, predictive phenomenological models. Reduced reliance on calibration will ensure the development of robust ASC simulation tools, These tools are intended to enable the understanding of the complex behaviors and effect of nuclear weapons, now and into the future, without nuclear testing.

[9] Performance measures were revised in 2007 to be consistent with new program roadmap.

Performance Indicators	FY 2007 Results ®	FY 2008 Results	FY 2009 Results	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016	Endpoint Target (T)
ASC Impact on SFI Closure: The cumulative percentage of nuclear weapon Significant Finding Investigations (SFIs) resolved through the use of modern (non-legacy) ASC codes, measured against all codes used for SFI resolution. (Long-term Outcome)[a]	R: 25% T : 25%	R: 37% T: 37%	R: 50% T: 50%	T: 60%	T: 65%	T: 70%	T: 80%	T:85%	T:100%	T:100%	By 2015, ASC codes will be the principal tools for resolution of all SFIs. This demonstrates how valuable the ASC tools are for meeting the needs of the weapon designer's analysts by documenting the impact on closing SFIs.
Code Efficiency: The cumulative percentage of simulation turnaround time reduced while using modern ASC codes. (Efficiency)[a]	R: 7% T : 7%	R: 13% T: 13%	R: 13% T: 13%	T: 15%	T: 20%	T: 27%	T: 34%	T: 42%	T: 50%	T: 50%	By 2015, achieve a 50% reduction in turnaround time, as measured by a series of benchmark calculations, for the most heavily used ASC codes. To show code efficiency by demonstrating that simulation time decreases as the ASC codes mature.

Appendix B.
ASC Risk Management Process

ASC risk management consists of three major components: Assessment, Mitigation, and Tracking.

Risk Assessment

Risk assessment involves identification, analysis, and contingency planning. The objective of risk assessment is to prioritize risks so that management may focus efforts on mitigating top risk items (Table B-1 and Table B-2). There are five different ASC risk types: Programmatic, Technical, Cost, Schedule, and Performance.

- *Cost Risks* – Not enough money at the highest level to do the job required in the time allocated.
- *Performance Risks* – One or more performance requirements may not be met because of technical concerns, or issues of competence, experience, organizational culture, and management team skills.
- *Schedule Risks* – Not enough time exists at the highest level to do the required job with the resources allocated.

Risk Mitigation

Risk mitigation is proactively undertaken to lessen consequence or likelihood and/or to develop contingency actions if risk issues develop (Table B-3). There are four different risk-handling methods: Avoidance, Control, Assumption, and Risk Transfer.

Risk Tracking

Risk tracking involves tracking the progress and status of mitigation actions and of risks. Risk status and evaluations can be found in quarterly progress reports, as well as in DP status reports.

Table B-1 on the next page evaluates consequences against cost, performance, and schedule.

Table B-1. Consequence Criteria

Consequence	Criteria
Very Low	**Cost:** Negligible impact on cost. Impact is contained within the strategic unit and results in neither under costing nor over costing of spend plan. **Performance:** Negligible impact on function or performance. Requirements are clearly met. **Schedule:** Negligible impact on schedule. Impact is managed within the strategic unit. Results in no impact to critical path and no impact to other strategic units. Milestones are clearly met.
Low	**Cost:** Minor impact on cost. Impact is contained within the strategic unit and results in less than 5% under costing or less than 5% over costing of spend plan. **Performance:** Minor impact on function or performance. Requirements are clearly met. **Schedule:** Minor impact on schedule. Impact may be managed within the strategic unit. Results in no impact to critical path and no impact to other strategic units. Milestones are clearly met.
Moderate	**Cost:** Recognizable impact on cost. Impact is not contained within the strategic unit and may result in less than 5% under costing or greater than 5% over costing of spend plan. **Performance:** Recognizable impact on function or performance. Requirements may not all be met. **Schedule:** Recognizable impact on schedule. Impact may not be managed within the strategic unit. May result in impact to critical path or may impact other strategic units. Milestones may not be met.
High	**Cost:** Significant impact on cost. Impact is not contained within the strategic unit and may result in less than 10% under costing or greater than 10% over costing of spend plan. **Performance:** Significant impact on function or performance. Requirements will not all be met. **Schedule:** Significant impact on schedule. Impact will not be managed within the strategic unit. Will result in impact to critical path or will impact other strategic units. Milestones will not be met.
Very High	**Cost:** Major impact on cost. Impact will not be contained within the strategic unit and will result in less than 10% under costing or greater than 10% over costing of spend plan. **Performance:** Major impact on function or performance. Requirements cannot be met. **Schedule:** Major impact on schedule. Impact cannot be managed within the strategic unit. Will result in failure in critical path or will significantly impact other strategic units. Milestones cannot be met.

Table B-2 on the next page evaluates likelihood against programmatic or technical risks.

- *Programmatic Risks* – Refer to tasks that flow from, or have an impact on, program governance, and those risks that impact program performance.
- *Technical Risks* – Refer to performance risks associated with end items.

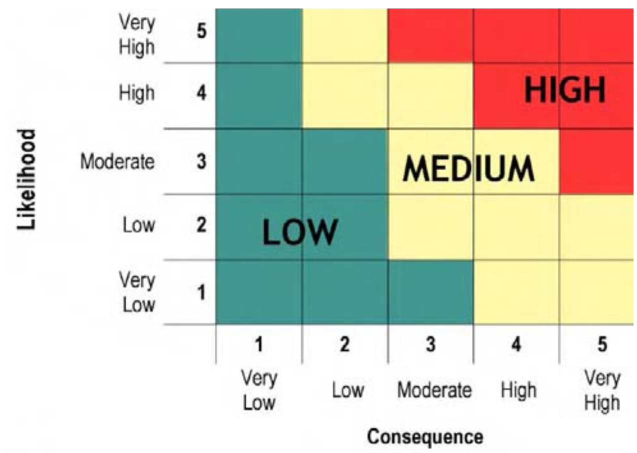
Table B-2. Likelihood Criteria

Likelihood	Criteria
Very Low	**Programmatic:** No external, environment, safety, and health (ES&H), security, or regulatory issues. Qualified personnel, resources, and facilities are available. **Technical:** Non-challenging requirements. Simple design or existing design. Few and simple components. Existing technology. Well-developed process.
Low	**Programmatic:** Minor potential for external, ES&H, security, or regulatory issues. Minor redirection of qualified personnel, resources, or facilities modification is necessary. **Technical:** Low requirements challenge. Minor design challenge or minor modification to existing design. Moderate number or complex components. Existing technology with minor modification. Existing process with minor modification.
Moderate	**Programmatic:** Moderate potential for external, ES&H, security, or regulatory issues. Moderate redirection of qualified personnel, resources, or facilities modification is necessary. **Technical:** Moderate requirements challenge with some technical issues. Moderate design challenge or significant modification to existing design. Large number or very complex components. Existing technology with significant modification. Existing process with significant modification.
High	**Programmatic:** Significant potential for external, ES&H, security, or regulatory issues. Significant redirection of qualified personnel, resources, or facilities modification is necessary. **Technical:** Significant requirements challenge with major technical issues. Significant design challenge or major modification to existing design. Large number and very complex components. New technology. New process.
Very High	**Programmatic:** Major potential for external, ES&H, security, or regulatory issues. Major redirection of qualified personnel, resources, or facilities modification is necessary. **Technical:** Major requirements challenge with possibly unsolvable technical issues. Major design challenge or no existing design to modify. Extreme number and extremely complex components. Possibly no technology available. Possibly no process available.

Table B-3 below evaluates risk exposure, based on consequence and likelihood. Different risk-handling methods that relate to this exposure include:

- *Avoidance* – Uses an alternate approach, with no risks, if feasible. This approach can be applied to high and medium risks.
- *Control* – Develops a risk mitigation approach/action and tracks the progress of that risk. This approach is mostly applied to high and medium risks.
- *Assumption* – Accepts the risk and proceeds. This approach is usually applied to low-risk items.
- *Risk Transfer* – Passes the risk to another program element. This approach can be applied to external risks outside the control of the ASC Program.

Table B-3. Risk Exposure Level Matrix



The risk-exposure values and the resulting matrix categorize risks as high, medium, or low. When risk exposure is high, a mitigating or contingency plan is required. When risk exposure is medium, a mitigating or contingency plan is recommended. When risk exposure is low, developing a mitigating or contingency plan is optional.

Appendix C.
ASC Management Structure

To ensure successful execution of the ASC strategy, an organizational structure, program-management process, and a performance-measurement mechanism have been instituted within the ASC tri-lab framework.

Organization

ASC's organizational structure is designed to foster a focused, collaborative effort to achieve program objectives. The following elements make up this structure:

- **Executive Committee.** This body consists of a high-level representative from each NNSA laboratory and a senior member in the Advanced Simulation and Computing Office at NNSA Headquarters (HQ). The Executive Committee sets overall policy for ASC, develops programmatic budgets, and oversees the program execution.
- **Sub-Program Management Teams.** These teams are responsible for planning and execution of the implementation plans for each of the ASC sub-programs: Integrated Codes; Physics and Engineering Models; Verification & Validation; Computational Systems and Software Environment; and Facility Operations and User Support. These management teams have a primary and alternate representative from each laboratory, and the corresponding sub-program manager from NNSA-HQ. These teams work through the executive committee. Tasking from NNSA-HQ for these teams originates from the ASC Federal Program Manager and is communicated through the executive committee.
- **ASC's NNSA-HQ Team.** This team consists of NNSA federal employees and contractors, in concert with laboratory and plant representatives. The ASC HQ team is responsible for ensuring that ASC supports the SSP. The team facilitates ASC interactions with other government agencies, the computer industry, and universities. In addition, the team sets programmatic requirements for the laboratories and reviews management and operating contractor performance.

Program Management Planning and Execution Process

ASC program management uses a planning process made up of elements described below (Figure C-1). All planning activities follow the product-focused national work breakdown structure reflected in the Business Model.

- **ASC Program Plan (PP)—**This document provides the overall direction and policy for ASC. This functions as a strategic plan, and it identifies key issues and work areas for ASC in the next six years. This document is reviewed annually to ensure that ASC supports SSP needs.

- **ASC Implementation Plan (IP)—**This document is prepared annually and describes the work planned in two year intervals at each laboratory to support the overall ASC objectives.
- **Other ASC Strategy and Planning Documents**[10]**—**In addition to the above, ASC has also published a suite of strategy and planning documents. These include the ASC Strategy (NA-ASC-100R-04-Vol.1-Rev.0); the Business Model (NA-ASC-104R-05-Vol.1-Rev.1); the ASC Roadmap (NA-ASC-105R-06-Vol.1), Total Cost of Ownership (NA-ASC-108R-06-vol.1-Rev.0); the ASC Platform Strategy (NA-ASC-113R-07-Vol. 1); and the ASC Code Strategy (NA-ASC-108R-09-Vol. 1-Rev.0).
- **Program Milestones—**ASC milestones are a subset of NNSA National Level 1 and Level 2 milestones. Level 1 milestones are national priorities or have high visibility at NA-10 or higher levels. They usually require multisite and/or multi-program coordination, and provide integration across ASC, DSW, and the Campaigns. Level 1 milestones may be specific to ASC or meet other SSP objectives with significant ASC support. Level 2 milestones are designed to execute the ASC strategy, demonstrate the completion of advanced ASC capabilities, and often support ASC Level 1 milestones, DSW deliverables, and/or major Campaign milestones.

ASC sets requirements for a Certification of Completion, constituting a body of evidence to certify completion of Level 2 milestones. Level 3 milestones demonstrate the completion of important capabilities within a program element and measure technical progress at the sub-program level; these milestones are laboratory-specific and are managed by the laboratories. Progress on Level 1 and Level 2 milestones is recorded in the NNSA Milestones Reporting Tool (MRT) and is reported quarterly to the Defense Program Director (NA-10) via the Quarterly Program Reviews (QPR) meetings and annually to the NNSA administrator (NA-1) via the annual technical review meetings.

- **Program Collaboration Meetings—**The following meetings facilitate collaboration among the three national laboratories, industry, and universities:
    - *Principal Investigator Meetings.* These bi-annual meetings provide a forum for ASC principal investigators to meet and discuss progress in their respective research areas. These meetings allow principal investigators at each laboratory to present and discuss their work with their peers at the other laboratories. In addition, the meetings include participants from outside the weapons laboratories in order to provide broader ASC peer review. The meetings also serve as an annual technical review for the DOE-HQ team.
    - *Executive Committee Meetings.* The ASC Executive Committee meets twice a month, via teleconference. These meetings ensure that relevant

[10] http://www.sandia.gov/NNSA/ASC/pubs/pubs.html

issues are identified, discussed, and resolved in a timely manner. The teleconferences are supplemented with quarterly face-to-face meetings as needed.

- *Sub-Program Meetings.* ASC program element teams conduct individual meetings to discuss progress, issues, and actions. The frequency of these meetings vary by discretion of the ASC HQ program manager and their counterparts at the laboratories. These meetings identify issues that need to be elevated to the Executive Committee.

- **Reviews**
  - *External Reviews.* External reviews are conducted regularly by the laboratories to provide independent, critical insight to the laboratories on the technical progress of the ASC Program. The review panels consist of experts from academia, industry, and the national laboratories. Results of the reviews are provided to the laboratories and ASC HQ observers. These reviews augment other high-level reviews.
  - *Internal Program Reviews.* Program reviews are organized at various levels to provide adequate assessment and evaluation of the ASC program elements. Each laboratory and each program element determines the scope and nature of the review as well as the form of reporting the results of such reviews that best suits its needs.

- **Performance Measurement**
  - This includes performance indicators and annual performance targets, established to annually measure the successful execution of the program (see Appendix B).

Laboratory managers are responsible for measuring and managing the performance of the projects within their purview. Each laboratory reports quarterly performance to NNSA in the form of accomplishments and progress toward Level 1 and 2 milestones.

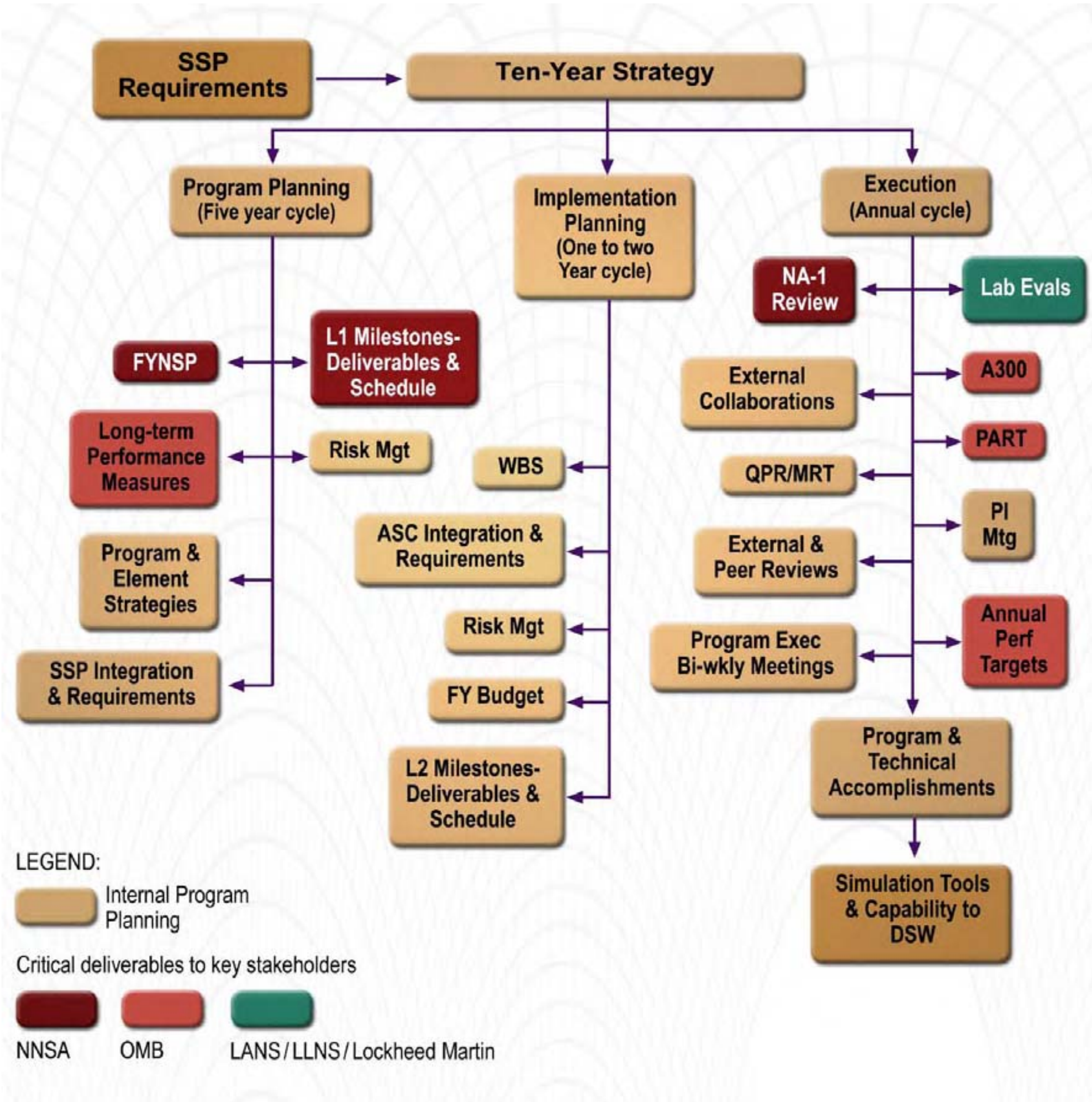


Figure C-1. ASC Program Planning and Evaluation Activities

Appendix D. Glossary

ACES
The NNSA New Mexico Alliance for Computing at Extreme Scale (ACES) is an NNSA ASC alliance between LANL and SNL devoted to providing High Performance Capability Computing assets required by NNSA's stockpile stewardship mission. The Alliance was formed through a Memorandum of Understanding between the two Laboratories executed in 2008.

AGEX
Above-ground experiment

ASC
Advanced Simulation and Computing Program. This program evolved from merging of the Accelerated Strategic Computing Initiative and the Stockpile Computing Program. The use of the acronym "ASCI" has been discontinued.

ASCI
Accelerated Strategic Computing Initiative

ASCI Blue Mountain (retired)
A Silicon Graphics, Inc. (SGI) system located at LANL. In 1998, ASCI Blue Mountain was installed as a 3.072-tera-FLOPS computer system.

ASCI Blue Pacific (retired)
An IBM system located at LLNL. In 1998, ASCI Blue Pacific was installed as a 3.89-teraFLOPS computer system.

ASCI Red (retired)
An Intel system located at SNL. ASC Red was the first teraFLOPS platform in the world when it was installed in 1998 (1.872 teraFLOPS). Processor and memory upgrades in 1999 converted ASCI Red to a 3.15-teraFLOPS platform.

ASCI Q (retired)
A Compaq, now Hewlett-Packard (HP) system located at LANL. ASCI Q is a 20-teraFLOPS computer system, delivered in FY 2003.

ASCI White (retired)
An IBM system located at LLNL. In 2000, ASCI White was installed as a 12.3-teraFLOPS supercomputer system.

Capability/capacity systems
Terminology used to distinguish between systems that can run the most demanding single problems versus systems that manage aggregate throughput for many simultaneous smaller problems.

CSSE
Computational Systems and Software Environment

DARHT
The Dual Axis Radiographic Hydrodynamic Test Facility at LANL, which examines implosions from two different axes.

DARPA
Defense Advanced Projects Research Agency

DoD
U.S. Department of Defense

DOE
U.S. Department of Energy

DP
Defense Programs, one of the three major programmatic elements in NNSA.

DSW
Directed Stockpile Work, those SSP activities that directly support the day-to-day work associated with the refurbishment and certification of specific weapons in the nuclear stockpile.

EOS
Equation-of-state

ES&H
Environment, safety, and health

exaFLOPS
One quintillion or one million trillion floating-point operations per second. ExaFLOPS is a measure of the performance of a computer.

LANL
Los Alamos National Laboratory, a prime contractor for NNSA, located in Los Alamos, New Mexico, and operated by LANS, LLC.

LEP
Life Extension Program whose purpose is to refurbish and/or replace nuclear weapons parts, including, but not limited to, those with limited lifetime.

LLNL
Lawrence Livermore National Laboratory, a prime contractor for NNSA, located in Livermore, California, and operated by LLNS, LLC.

M&S
Modeling and simulation capability

MESA
The Microsystems and Engineering Sciences Application Facility at SNL/NM, which provides the design environment for (nonnuclear?) micro-system components of a nuclear weapon.

NIF
National Ignition Facility

NNSA
National Nuclear Security Administration, a semi-autonomous agency within DOE.

NPR
Nuclear Posture Review

nWBS
National work breakdown structure

NWC
Nuclear Weapons Complex

PEM
Physics and Engineering Models

Petabyte
1015 bytes; 1,024 terabytes

petaFLOPS
1000 trillion floating-point operations per second. PetaFLOPS is a measure of the performance of a computer.

PP
Program Plan

QMU
Quantification of margins and uncertainties

R&D
Research and development

RRW
Reliable Replacement Warhead

Science-based
The effort to increase understanding of the basic phenomena associated with nuclear weapons, to provide better predictive understanding of the safety and reliability of weapons, and to ensure a strong scientific and technical basis for future U.S. nuclear weapons policy objectives.

SFI
Significant Finding Investigation. An SFI results from the discovery of some apparent anomaly with the enduring stockpile. DSW Surveillance generally initiates an SFI. For complex SFIs, resolution comes from the Assessment & Certification element of DSW, often in partnership with ASC capabilities.

SNL
Sandia National Laboratories, a prime contractor for NNSA with locations primarily in Albuquerque, New Mexico, and Livermore, California. Operated by Lockheed Martin Corporation.

SSP
Stockpile Stewardship Program, DP's response to ensuring the safety, performance, and reliability of the U.S. nuclear stockpile.

STS
Stockpile-to-target sequence, a complete description of the electrical, mechanical, and thermal environment in which a weapon must operate, from storage through delivery to a target.

teraFLOPS
One trillion floating-point operations per second. TeraFLOPS is a measure of the performance of a computer.

Test-based
The traditional approach used for the development of nuclear weapons, based on full-scale nuclear tests.

Tri-lab
Refers to the three NNSA laboratories: LLNL, LANL, and SNL.

UGT
Underground test (usually nuclear)

UQ
Uncertainty quantifications

V&V
Verification and Validation. Verification is the process of confirming that a computer code correctly implements the algorithms that were intended. Validation is the process of confirming that the predictions of a code adequately represent measured physical phenomena.

Terabyte
Trillions of bytes, abbreviated TB, often used to designate the memory or disk capacity of ASC supercomputers. A byte is eight bits (binary digit, 0 or 1) and holds one ASCII character (ASCII—the American Standard Code for Information Interchange). For comparison, the book collection of the Library of Congress has been estimated to contain about 20 terabytes of information.

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